Canadian
Environmental
Advisory
Council

Report No. 8
August 1979

ECOTOXICITY: RESPONSIBILITIES AND OPPORTUNITIES

Ross H. Hall
Donald A. Chant

Canadian
Environmental
Advisory
Council

Report No. 8
August 1979

ECOTOXICITY: RESPONSIBILITIES AND OPPORTUNITIES

Ross H. Hall
Donald A. Chant

OTTAWA, CANADA
1979

CANADIAN ENVIRONMENTAL ADVISORY COUNCIL

The Canadian Environmental Advisory Council was established in 1972 by decision of the federal Cabinet, to advise the Minister of the Environment on:

- such matters as may specifically be referred to it by the Minister;
- the state of the environment and threats to it;
- the priorities for action by the federal government or by the federal government jointly with the provinces;
- the effectiveness of activities of the Department of the Environment in restoring, preserving or enhancing the quality of the environment.

The Council is composed of up to sixteen members who serve in an individual capacity and are drawn from a wide cross-section of Canadian life and from all across Canada. Officials of the Department of the Environment are not members of the Council; however the Department provides a continuing Secretariat.

To carry out its functions the Council undertakes studies and reviews of matters of environmental concern and policy, holds regular meetings to consider progress and developments with regard to these concerns, and prepares comments, statements and reports as appropriate. The Council publishes an *Annual Review* which includes a summary of the state of the environment in Canada, and from time to time reports on other matters of general interest and importance.

Cat. No. En 93-8/1979
ISBN 0-662-10737-3

N° de cat. En 93-8/1979
ISBN 0-662-10737-3

Enquiries concerning the work of the Council and requests for Council publications should be addressed to:

The Executive Secretary
Canadian Environmental Advisory Council
c/o Department of the Environment
Ottawa, Canada
K1A 0H3

PREFACE

One of the most daunting environmental problems of our time arises from the flood of man-made chemicals pervading out lives. The products or by-products of our industries, they are in every home in a multitude of forms - floor coverings, insulation material, varnishes, synthetic fabrics, washing agents, medicines, sealants, hair sprays and antiperspirants, toys, vinyl clothing, pest killers - in variety too numerous to list. The ingenuity of those who have contrived new chemical compounds and devised ways of inserting them into our economy in useful forms or new processes has had much to do with the improvement of the human state.

We have too frequently ignored the other side of the coin. To our distress, we have slowly learned that some of these products are damaging to human health. For some of these, we have developed restrictive legislation which we hope will protect us. But the ultimate fate of every compound is to be discharged via the sewer or the incinerator stack or by accident into the air, the water or onto the land, where singly or in combination they alter the environment. Species are destroyed, lakes and rivers lose their ability to support their normal faunas, vegetation changes; the habitats upon which life forms depend become less suitable as places for plants, animals and man to survive.

The Canadian Environmental Advisory Council has identified this predicament as one of the most urgent priorities among environmental problems facing Canadians. Dr. Ross H. Hall of the Department of Biochemistry, McMaster University, and Dr. Donald A. Chant of the Department of Zoology, University of Toronto, undertook, on behalf of the Council, the study on which this report is based. It identifies the main issues, illustrates the extent of our ignorance and discusses the inadequacy of our facilities to train the specialists required. Finally, in recommendation form, it sets out courses of action and responsibilities.

It is urgent that Canadians clearly grasp the extent and insidiousness of this threat to the livability of our environment. It is imperative that they support the slow, undramatic, costly, perhaps uncomfortable but undeniably essential steps to redress the rapidly accelerating environmental deterioration caused by the agents discussed in this report.

Ian McTaggart-Cowan
Chairman

CANADIAN ENVIRONMENTAL ADVISORY COUNCIL

Members

Dr. Ian McTaggart-Cowan
Victoria, British Columbia
Chairman

Dr. Philippe Garigue
Montréal, Québec
Vice-Chairman

Dr. David Ahenakew
Prince Albert, Saskatchewan

Mr. Thomas Beck
Calgary, Alberta

Mr. Robert Bergeron
Chicoutimi, Québec

Mr. Richard Brown
Yellowknife,
Northwest Territories

Dr. Donald A. Chant
Toronto, Ontario

Mr. Jean Chollet
Montréal, Québec

Dr. Mervyn Franklin
Windsor, Ontario

Dr. Ross H. Hall
Hamilton, Ontario

Mr. Trevor G. Jeanes
Kamloops, British Columbia

Ms. Marjory J. Loveys
Toronto, Ontario

Mr. H. Douglas McRorie
Winnipeg, Manitoba

Secretariat

Dr. E. Fred Roots
Executive Secretary

Dr. J. Keith Fraser
Associate Secretary

Ms. Veena Halliwell
Administrative Assistant

August 1979

TABLE OF CONTENTS

ABSTRACT

Society has created a vast chemical industry that affects all aspects of our life, so much so that without chemicals our technological lifestyles would grind to a halt. The industry now generates for every inhabitant of North America over one ton of chemicals a year, comprising more than 60,000 different substances. This immense production, in some form, eventually ends up in the environment. And by their every nature, once in the environment, chemicals penetrate living organisms, creating a generalized phenomenon that we call ecotoxicity. It is an insidious form of toxicity because, by virtue of interdependence, the life-support systems of all living organisms become toxic.

Policies founded in the last century, when production was a tiny fraction of that produced today, allowed anyone to make, sell and dispose of any chemical without regulation (except a few well-defined poisons and chemicals in food, drugs and pesticides). The realization that these policies could not continue stimulated proclamation of the Environmental Contaminants Act (1976) which laid the basis for regulation of all chemicals not covered by existing legislation.

Years of blindness to the growing seriousness of ecotoxicity has left a legacy of indifference to the study of the effects of chemicals in the environment. The sudden need for some kind of scientific basis for regulation has elevated a hitherto lacklustre and weak science, toxicology, to the fore. Unfortunately, this science is limited to studying the effects of single chemicals in a laboratory setting. The Act itself reflects the limited capabilities of the science.

The serious flaw in this legislation is that it tries to control contamination by each chemical as if it were an isolated pollutant. Furthermore, the Act cannot be enforced until details of contamination and harm are known. Ecotoxicity results not from single chemical but from the intervention of a multitude of chemicals. It is simultaneous, multi-causal and indiscriminate. We know ecotoxicity exists, but because of the weakness of the relevant science, details generally are lacking. Nevertheless, we must develop policies that control contamination from the point of view of the environment as a whole.

The present attitude assumes that the environment can carry a certain amount of contamination; the purpose of control is to regulate the degree. This is a false assumption, because we do not know to what degree contamination can be tolerated. A policy of moving toward zero contamination (even though it is recognized this cannot be achieved) is recommended and that control should be directed toward this end, recognizing that this policy will require time and a major educational program.

At this juncture, Council makes the following recommendations to the Department of Environment: i) Reorganize Departmental responsibilities to reflect the seriousness of ecotoxicity. ii) Implement policies that will encourage the development of technologies that are not so dependent on chemicals. iii) Develop policies that will require chemical manufacturers and users to be responsible for the ultimate disposal of all chemicals. No chemical should be manufactured or sold if it cannot be recycled or disposed of harmlessly. iv) Found centre(s) of training that will further the science and practice of ecotoxicology and the public understanding of ecotoxicity.

I. INTRODUCTION

Lord Bertrand Russell wrote: "One of the troubles of our age is that habits of thought cannot change as quickly as techniques, with the result that as skill increases, wisdom fades."[1] Lord Russell's comments are particularly relevant to the natural environment, because in the last few decades society's skills have enormously modified the environment. Yet many of our attitudes and policies that affect the environment remain old-fashioned, reflecting a past era when environmental change was much less pronounced or at least not as noticeable to the public. Westernized countries have been able to push ahead in the past with massive industrial development without much regard for environmental quality. Indeed, many still pay only lip service to environmental concerns. Implicit in their actions has been the assumption that the environment is infinitely resilient, able to withstand almost any pressure. Canada, with its large land mass relative to population, has been particularly vulnerable to this habit of thought.

Two Principal Issues:

Two principal policy issues for Canada arise at this stage in her economic evolution, both of which are neatly crystallized in Lord Russell's comment.

1) Laissez-Faire: Rapid industrialization was carried out during an era of limited understanding of environmental effects and public health. This era is akin to the early era of economic laissez-faire. This doctrine, long discarded in economic circles, appears very much alive in terms of policy affecting the environment. Most industrial and government policies have an environmental component whether or not stated, but this component has often received low priority. In effect, by ignoring that component, society ignores the fundamental biological nature of humans and their organic relationship with the environment. The economic reality is that the industrial and commercial activities now in place have been created without regard to environmental reality and, moreover, society as a whole has developed neither the skills nor the wisdom to create industrial wealth without serious environmental impact.

2) Ignorance: Although a vast amount of documentation concerning environmental degradation has accumulated, society remains relatively ignorant of its biological significance. We know in a gross way that pollution from a steel mill increases human illness and destroys aquatic life, yet we are unable to document the subtle effects, or the overall significance to environmental well-being. We know that most lake fish in Canada are contaminated with polychlorinated biphenyls (PCBs) and that these chemicals are highly toxic, but we cannot interpret precisely the significance of this information.

The long period of environmental laissez-faire has discouraged the development of a wisdom that would guide Canadian industrial development in a manner compatable with maintenance of environmental integrity.

The Central Challenge:

The central challenge, therefore, facing Canadian policy makers is how to acquire that wisdom and reduce it to action. What is environmental wisdom? It may mean acquiring new knowledge in the environmental field, although that may take decades, and we can ask: What types of knowledge do we need? But the urgency of decision-making, however, does not permit the luxury of waiting, and so environmental wisdom requires development of policies suitable for both the short term and for the long term. It means the development of skills to use creatively existing knowledge and understanding, all the while recognizing our environmental ignorance.

Formation of federal and provincial Departments of Environment and enactment of legislation since 1970 heralded an intent to abandon the doctrine of environmental laissez-faire and to mold effective social and fiscal policy towards the environment. But in many cases governments have been slow to act and the legislation enacted is inadequate to meet the reality of the situation. A more vigorous approach to policy-making is urgently needed.

Ecotoxicity; A Definition:

Chemicals and chemical technology dominate all facets of our industrialized society, not only through the established chemical industry, but through almost every other industrial and commercial activity. Use, waste and ultimate discard of chemicals in all forms pervade the environment in massive and insidious ways. Their rapid dispersion and invasive power make it impossible to localize their effects. Consequently, the whole environment, including humans, is being contaminated in a sea of chemicals. The term for this environmental defilement is ecotoxicity.

Ecotoxicity is one of the major threats to the quality of the Canadian environment, a threat made all the more serious by ignorance about ecotoxicity, lack of technical solutions and inadequate governmental policies. Underlying the weak response to the threat is the long-held attitude of laissez-faire; by and large, anyone has an unrestricted right to make, sell, distribute or dispose of chemicals.*

---

*Certain categories of chemicals, drugs and pesticides are indeed regulated, but about 90 percent of all manufactured chemicals did not fall into any regulated category until passage of the Environmental Contaminants Act in 1976.

II. ECOTOXICITY: SIX PROBLEMS

1) Nature of Ecosystems: Undesirable Chemical Integration

The essence of an ecosystem is one of constant transformation. One species becomes food for the next in the food chain. The molecules of all our cells are constantly turned over; even our bones are constantly being renewed. Nothing is static in a living organism or in the ecosystem as a whole. One major concern is the way in which foreign chemicals invade the biotransformations of the ecosystem, in fact becoming part of them. They move through the ecosystem in strange and unpredictable ways.

Mercury metal, for example, as recently as 1970, was thought to lie inertly anywhere it was discharged. It has now been discovered that micro-organisms in the bottom mud of rivers and lakes transform the mercury to methyl mercury which is soluble in the water and highly toxic to water life. The concentration of toxic methyl mercury becomes magnified as it moves up the food chain to the point where fish themselves may become lethal, which is why Indians have been discouraged from eating fish taken from mercury-contaminated lakes and rivers.

The toxic effects of chemical contaminants often manifest themselves in subtle ways - diminished reproductive capacity, deformed offspring, mental aberrations such as loss of ability to learn, as shown in trout exposed to DDT and other such chemicals. Our concern stems from two aspects: our survival and well-being depend on the living ecosystem of which mankind is a part, and if chemicals are injuring other species, what are they doing to mankind?

The problem for society is that once a chemical enters the environment, it is impossible to control or contain. It is changed, accumulated, and transported indiscriminantly by water and air. It may interact synergistically with other contaminants and natural components of the ecosystem. It may become integrated into the molecular processes of each living organism. Laboratory approaches are unable to predict the fate and effects of a chemical once unleased into the environment. A systematic system of monitoring the fate and effects of chemicals once loose in the environment has not been developed, and there seems to be no plan to develop one.

It is important to the understanding of the thesis of this report that most man-made chemicals cannot remain neutral in a living process. They are either a nutrient or a drug (poison). In the absence of precise evidence, we must assume that all man-made chemicals* are poisons with power to modify, often irreversibly, the growth and life of all organisms.

2) Chemical Growth

Since the end of World War II, growth in the number and volume of chemicals produced has exploded. In the 25 year post war period, for example, the use of mercury for manufacturing chlorine, an excellent index of chemical production, increased 40 times; production of synthetic fibres increased 60 fold; and the production of synthetic organic chemicals increased 10 times[2]. Production in the United States of the 50 top chemicals in 1977 totalled 240 million tons, over one ton for every person in that country. The growth rate for the top 50 is 3.6 percent per annum, led by the 29 top organic chemicals on the list which are growing at 8 percent per annum[3].

The Environmental Protection Agency (EPA) in the United States has estimated that there are about 63,000 chemicals in commercial use[4]. Commercial chemicals, however, are never pure and, therefore, the actual number of chemical species could well be over 200,000.

*Mercury and other metallic poisons are not man-made chemicals, but through human activity they are redistributed in unnatural ways.

Most of these substances are new to Nature, consequently it has had no time to evolve the benign mechanisms necessary to deal with them. Nature must deal with them, however, because chemicals, in some form, in some way, eventually end up in the environment. And, to re-emphasize, the invasive feature of chemicals is that, unlike waste autos and steam locomotives which remain as discrete entities, they permeate uncontrollably all living processes, including those of humans.

The adipose tissue of all Canadians has become a rich repository for fat-soluble environmental contaminants, including large numbers of pesticides, flame retardants and industrial transformer fluids, all of which integrate into the body's metabolism.*

3) How Do We Know The Environment Is Altered?

The question highlights Lord Russell's comment on wisdom declining relative to the advance of technological skills. Society has failed to develop the sensitive antennae necessary to monitor environmental changes as well as the judgmental mechanisms necessary to assess the harmful effects of chemicals on all aspects of environmental viability, including human life. We indeed have some forms of antennae, but they work imperfectly; the messages they deliver are either too gross or, if they are detailed enough, the data cannot be interpreted. We know enough, however, to conclude that the large amount of chemical contamination already in the environment has begun to compromise human health and environmental quality.

The incidence of goitres in Great Lakes Coho salmon has increased significantly in recent years, now occurring in as many as 80 percent of the fish in some areas. Similarly, the incidence of tumors on the lips of white suckers is rising and is now as high as 51 percent in the industrial urban complex along Lake Ontario[5]. Once again, the significance of these data is unknown in human or ecological terms, but by their very nature, we must be disturbed by them. The need to integrate and understand the organic patterns of the ecosystem and how they are affected *in toto* by chemical agents is imperative.

4) Risk/Benefit Assessment

Over the last ten years a considerable body of legislation that bears on environmental quality has been passed in Canada. Implicit in all this legislation is the assumption that risk/benefit judgements can and should be made. Risk/benefit decisions have been in operation for a long time in those laws related to drug regulation. Whereas a risk/benefit ratio for a single drug-single patient can be reasonably well-defined, analogous definitions when dealing with environmental issues are not valid. The criteria for defining environmental risks differ radically from those used to define benefits.

Risks concern people, animals, water quality, essential life processes, and in general can be stated only vaguely. Benefits, in contrast, are declared in precise terms - industrial production, jobs, investment, and so on. The attempt to rationalize risk/benefit assessment will never be worked out satisfactorily until a common basis of definition can be developed.

---

*There is a tendency to distinguish between readily biodegradable chemicals and those which persist in the environment for a long time. The latter are considered the more serious. However, in the very act of bio-degrading, a contaminant may stress the system doing the degrading. It would be a dangerous assumption to assume that because a substance bio-degrades, it is benign. Some of the most toxic (to humans) synthetic chemicals known are the nerve gases or cyanide which indeed are degraded by the human body - too late!

5) Personal Attitude to Risk

In making collective judgements about risk, it is hard to avoid personal attitudes towards risk. Many people become concerned with their health only when they lose it. People willingly and knowingly accept the strongest personal risks such as smoking and excessive drinking. Part of the difficulty lies in an individual's perception of the future, particularly when the connection between cause and effect seems tenuous. These attitudes spill over into attitudes about the environment which bear on the public's willingness to support environmental decisions. On the other hand, when the issues are defined more precisely, people will support reasonable measures. Dealing with personal and public attitudes complicates environmental decision-making, but it should be obvious that those attitudes are more easily manipulated when knowledge and understanding are limited.

6) Oversimplification

In an attempt to develop a more scientific approach to environmental issues, there has been a tendency to oversimplify the issues. Lord Eric Ashby, formerly Chairman of the United Kingdom Royal Commission on Environmental Pollution, said in 1977 that if one tries to simplify too much, the issue becomes drained of all meaning. In this sense he disparaged the tendency to analyze, because analytical figures in themselves do not necessarily give any insight.

There are analyses of mercury in fish from all parts of Canada, for example, but no one can interpret with assurance the significance of these data or the harm actually being caused. The simple expedient of arbitrarily setting an analytical threshold of mercury in fish above which the fish should not be eaten, as has been done in most western countries, does not really address the problem.

III. LIMITS TO KNOWLEDGE

In order to have a firm basis on which to make policy decisions, it is necessary to understand the limits to knowledge and the reasons for those limits.

One tends to be so overawed by scientific and technical achievements in such sectors as computers, space, nuclear power or synthetic fibres that it is hard to realize that, by comparison, science and technology in the environmental sector is extremely backward. The inability to specify precisely the significance of mercury in fish is one example of the limits of scientific knowledge. And the inability to do anything about mercury contamination, once occurred, underscores the limits of technology.

Because of these technical limits for remedial action, authorities have recognized that it is imperative to control chemical contamination at the source. But effective control depends on having an effective science to provide the basis for that control. In fact, by acting as if an effective science did exist, policy-makers endanger formulation of a more rational attempt to re-establish environmental quality.

Although our skills for making chemicals and for analyzing their presence are superb, our efforts at describing the impact of chemicals on the living processes of the environment are rudimentary. In this age of the flowering of biological science, why should this be so? This question may be answered by describing the status of the science of toxicology, the study of the effect of chemicals in living creatures.

Toxicology: A Neglected Science

The sharpening concern over environmental contamination has elevated this hitherto neglected and lacklustre science to national prominence because much of the new environmental policy is based on it. In fact, policy is being shaped by what this science is capable of delivering.

Dr. Donald Kennedy, Commissioner, Food and Drug Administration (FDA), Washington, and himself a biologist, said that of all the biological disciplines, "only nutrition approaches toxicology in terms of being basically in bad shape." He attributed this to the fact that toxicology suffers from being a transdiscipline, cutting across several major fields, and consequently none of the parent disciplines takes any interest in toxicology[6]. Though he did not say so, Dr. Kennedy could have added that low prestige also plays a role. In the opinion of many biological scientists, toxicology smacks of so much number generation far removed from the exciting new ideas in the life sciences. As a consequence, it attracts too few of the innovative and the clever.

The inadequacies of toxicology fall into four categories: 1) Its methods of approach are too often based on the testing of a single chemical at relatively high doses; 2) It has failed to develop animal models or other test systems capable of predicting the behaviour of chemicals in humans; 3) Existing laboratory procedures are so laborious and turtle-paced that only a small number of chemicals can be studied; and 4) Toxicology is a laboratory science and offers little help in evaluating field experience, for example, the effects of eating PCB - rich fish.

Toxicology: In a Conceptual Backwater

The science of toxicology developed in the last century as the burgeoning chemical industry began to produce synthetic chemicals in quantity. At that time, scientists were concerned with whether or not individual chemicals would poison workers and users. Interest lay mostly in acute episodes. The science, in effect, was created to serve the chemical and pharmaceutical industries and this fact was significant in guiding its development, or to be more accurate, its lack of development. Although all the biological sciences underwent explosive development in this century, the science of toxicology remained in a conceptual backwater. Its procedures and conceptual approaches barely evolved at all. This can be illustrated by citing one of its principal working tools.

Lethal Dose (LD_{50})

Although human interpretation was the ultimate goal, the early toxicologists were forced into using animal models. Human experience was derived mainly in retrospect, by accidental exposure of workers, without the benefit of systematically designed experiments. The founders of toxicology, in developing animal models, accepted the admonishment that science was not science unless something could be measured. Thus, in the search for a quantitative basis, the notion arose of killing off half the animals in an experimental group. Any group of experimental rats, for example, will vary in its response to toxic substances. A given dose might kill some, sicken others, and still others would seem to have suffered no harm.

By giving groups of test animals graded doses of a single chemical it is possible to specify a dose that kills one half of the animals in the group. This value became known as the lethal dose, 50 percent or LD_{50}. The LD_{50} of a given chemical differs from species to species and this variability makes it difficult, if not impossible, to extrapolate from animal experiments what the LD_{50} would be for humans.

Relevance of LD_{50} Values

Toxicologists design their experiments as if they were running a chemical reaction in a laboratory. They hold all the variables of the experiment constant except one, the test chemical. The animals used in the experiment are as identical as in-breeding permits. They are housed at constant temperature and humidity, their food is nutritionally balanced and their water is clean and plentiful. Stress of all kinds is eliminated. The test animals receive measured amounts of a single pure chemical and the toxicologists measure the death response statistically.

What is the relevance of this laboratory model of living organisms, including humans, exposed simultaneously to thousands of chemicals in their food, water and air under widely variable conditions? Very little, and yet it is this laboratory model that forms the basis today of official decrees of whether an environmental contaminant, a drug or a food additive, is harmful or "safe".

Do Animal Experiments Predict?

The nineteenth century toxicologists in actual fact carried their art to a higher level of sophistication. To ascertain what changes occurred in the animal's biology leading to its death, they turned to tissue pathology. This technique permitted them to ascertain what organs were effected by the chemical and it made possible the detection of subtle tissue damage before any gross signs of sickness appeared. The techniques of pathology, however, were developed primarily to study human tissue in order to diagnose diseases and the study of animal tissue never assumed any special purpose of its own.

Dr. G.E. Paget of Smith, Kline and French Laboratories, in acknowledging this weakness, wrote that the training of pathologists has classically been concerned with precise diagnosis of human disorders and not with functional assessment of the disorders, and even less with the predictive significance of the disorder to individuals of different species and under different circumstances[7]. The techniques of tissue pathology, while technically more advanced, have not changed conceptually since the nineteenth century. The pathologist is interested in diagnosing the illness of the human or animal patient. The "why" is ignored. Without knowledge of the "why", extrapolation of what is found in animal tissue to human and environmental experience is extremely unreliable.

Acture Versus Chronic

It is quite clear that toxicology has been a science based on acute episodes, and is principally concerned with the amounts of a chemical capable of generating such episodes. Apart from immediate poisoning episodes, the serious problems facing the environment are the long term chronic effects.

The human body in some ways is a microcosm of the global environment and it presents us with a clear indication of the chronic effects of chemical contamination. These effects become known only after-the-fact.

Onset of human cancer occurs years after exposure. Only recently has a rash of cancer cases appeared among individuals who worked in wartime ship yards lagging pipes with asbestos. This cancer correlates with asbestos exposure, but most cancers cannot be identified with a particular cause. We must remember that 80-90 percent of all human cancer are due to environmental factors[8].

The procedures of classic toxicology for determining carcinogenicity in animals are laborious and fraught with opportunity for misinterpretation. The reason is that the classic procedures developed for study of acute effects can be extended only with difficulty to study of the long term effects. The essence of environmental toxicity is chronic exposure to low levels of pollutants. These classic procedures are unable to document the slow degradation within.

The natural environment, in effect, may seem to tolerate contamination for years, and as in the human, when it occurs, the breakdown is sometimes swift and final.

The Enormity of Tiny-ness

Classic toxicology has handed two conceptual legacies to policy-makers that make it very difficult for them to grapple with the hidden dangers of chemical contamination: 1) the insignificance of trace amounts, and 2) the concept of a threshold for each chemical below which no harm ensues.

Chemical and Engineering News, the major trade magazine of chemists and chemical engineers, once commented editorially on infinitesimal amounts[9]. One part per million (ppm) is equivalent to one inch in 16 miles, one minute in two years, one cent in $10,000 and one large mouthful of food compared with a person's lifetime of eating.

This commentary was intended to deride the biological significance of small amounts of chemicals. It is easy to see why chemists think this way because in most chemical experiments, traces of a foreign chemical in parts per million would be insignificant to them. In biological terms, small quantities of substances frequently distinguish between death and life.

Diethyl stilbesterol, a chemical commercially fed to beef cattle, induced malignant tumors in mice at a level below the official analytical sensitivity of two parts per billion[10]. Humans cannot live without vitamin B_{12}. Yet a person's daily requirement diluted by the total body fluid is the order of one part in a billion. Small quantities of substances are indeed critical to life processes. However, in determining policies on the significance of small quantities of chemicals in one's body or in one's environment, it is usually the chemist's view that dominates.

Toxicology was a science developed to serve the needs of the chemical and pharmaceutical industries and ever since the thinking patterns of chemists have molded the assumptions underlying toxicology. As a consequence, toxicology never developed the techniques to interpret the subtle biological effects of chemical contaminants present in parts per million, not to mention billion or trillion.

Over the Threshold

The concept of threshold holds that for every toxic chemical there is a level below which there is no apparent effect. The LD_{50} of a chemical can be determined and, so it is said, also the level at which there is no apparent effect on the test animals. Put more accurately, this is the level *below which toxicological technique detects no effect*. Large number of scientists and especially bureaucrats disregard this inherent limitation of science, and the concept of a real threshold for every chemical is firmly entrenched. The word threshold, however, is more a bureaucratic than a scientific judgment.

Because of the complexity of biological phenomena, any toxic substance affects countless processes within an organism, each presumably with a different threshold. Many effects become permanently fixed in the organism without the need for any subsequent exposure. A single exposure, for example, can set the cancer process in motion. For all practical purposes, there is an infinity of thresholds, and when bureaucrats set a value, to which threshold do they refer? Policy-makers tend to select one or two thresholds and proclaim these significant. Fish containing less than 5 ppm of epoxychlor (an environmentally persistent pesticide), for example, are claimed not to cross a threshold harmful to human eaters. These bureaucratic judgements ignore the state of health and of the eaters, the general quality of food they eat, the presence of other contaminants, and many other factors. Threshold, as a biological concept, defies legislation.

Legislation Shaped by Toxicology

The science of toxicology, in summation, deals with chemical contamination by 1) studying a single chemical at a time, 2) establishing acute short-term effects, and 3) working with relatively high levels of substances.

These approaches contrast with the reality of chemical contamination which consists of 1) a multitude of chemicals interacting simultaneously and synergistically, 2) effects which manifest themselves over the long-term, often irreversibly, and 3) low level contamination, parts per million and less.

Government legislation, in elevating toxicology to a dominant place in environmental policy-making, unwittingly absorbed the three dominant limitations of classic toxicology - single chemicals, acute effects and high dosage levels. In fairness to policy-makers, is there an alternative? Is there a science of ecotoxicology?

IV. ECOTOXICITY

Ecotoxicity remains a seemingly elusive concept, vague in details perhaps, but not vague in its overall approach to ecological reality. Ecotoxicology in direct contrast to classic toxicology deals with the multi-causal simultaneous effects of all substances, no matter how little, in the environment. There are many aspects of existing sciences that would contribute to the establishment of a distinct scientific activity in this area, ranging from molecular biology to geophysics.

An approach to carrying out an area of inquiry, promoted by the Scientific Committee on Problems of the Environment (SCOPE), uses the results, values and estimations of classic toxicology and incorporates these into studies of ecosystems[11]. The SCOPE approach focusses on the living processes of the environment and its objective is to develop six procedures that can integrate the sum total of environmental effects:

1) Basic features of biological responses to toxic agents, including tissues, reproduction, growth, immune system, life span, synergism of agents.

2) Animals: how sublethal effects on individuals may affect populations.

3) Aquatic animals: they are especially useful for integrating the effects of environmental contamination by virtue of the fact that all contamination tends to transfer eventually to water.

4) Plants: effects on normal community dynamics. Search for species that are particularly sensitive, e.g. lichens.

5) Micro-organisms: in particular, study of soil organisms.

6) Geophysical systems: study of ozone, weather changes, global transport of pollutants.

A danger lies hidden in these procedures because most information is generated retrospectively. Some environmental change must occur in order for it to be recorded. Nevertheless, such procedures are vital as a beginning to establishing a broadly based approach to ecotoxicity. The federal government has already recognized the need for support of this effort through contracts administered by the Associate Committee on Scientific Criteria for Environmental Quality of the National Research Council and a granting program of the Natural Science and Engineering Research Council (Environmental Toxicology).

The support provided, however, is miniscule in relation to the difficulty of the task and the seriousness of environmental degradation. The public seems to be ahead of government policy in this matter, their concern, albeit, heightened by media treatment of specific episodes, but back of these well-publicized occurrences lies the nagging feeling that much worse is happening of which they are unaware.

Well-Documented Examples of Ecotoxicity

1) Polychlorinated biphenyls (PCBs): These compounds exist as non-flammable, indestructible and electrically non-conducting oils. They have been widely used for 50 years as heat transfer fluids and in electrical transformers. During this period, there has been constant leakage as well as deliberate dumping in the environment, but only in the last 15 years has evidence of their extreme toxicity surfaced. At one part per billion (ppb), they kill species of shrimp. Birds are more resistant, but bioaccumulation of PCBs in the food chain result in lethal doses for many birds which subsist on aquatic life[12].

PCBs do not degrade in the environment and recycle endlessly. Fish in the Great Lakes system are now sufficiently contaminated to cause authorities to warn anglers not to eat very much of their catch. Contamination is not limited to the lower lakes where industrial activity is concentrated for Lake Superior has also become severely contaminated, apparently by atmospheric transport[13].

Contamination by PCBs represents a non-point source and exemplifies the lack of adequate means for disposing of this material. The Environmental Protection Service of Environment Canada has identified 17 million pounds in Ontario that require disposal. Regulation under the Environmental Contaminants Act now restrict the use of PCBs and the intent is to phase them out entirely. These rules, however, have no effect on the estimated ten million tons already released into the environment by the industrialized world[14].

2) Spruce budworm: In 1952, 200,000 acres of New Brunswick were sprayed with DDT, intended to control the spruce budworm[15]. Since that time both the infested acreage and the spraying operation have expanded. In 1976, 9.5 million acres were sprayed[16]. British Columbia, faced with the same problem, discontinued spraying and the degree of infestation subsided as natural control began to take effect.

DDT and its successors, <u>Sevin</u> and <u>Matacil</u>, are all highly toxic substances whose environmental toxicity has been inadequately studied. One manifestation of their toxicity has been the deaths of wild birds. Though the alleged benefits of the program have been vigorously challenged, the government of New Brunswick seems determined to continue the program.

This episode illustrates the prevalence of single cause-single effect thinking. An alleged benefit takes precedence over the wide-spread secondary effects on the ecosystem.

3) Seveso: In 1976 a small explosion in a chemical plant in Seveso, Italy released a few pounds of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD). This substance, one of the most toxic substances known, was sufficient to contaminate an area of 5 km long and 700 m wide[17]. The first noticeable effects were the deaths of pets and wildlife in the zone, and severe dermatitis, especially in children. The area was evacuated and decontamination was carried out to the extent practicable. Pregnant women were faced with a dilemma because TCDD causes birth defects. The full effects of this one small accident will not be known for years.

This incident stresses that human error can quickly cause severe contamination. Human error also played a major role in the next episode.

4) Polybrominated biphenyls (PBBs): In 1973 a workman in a chemical plant in Michigan interchanged some bags of chemicals. As a result, about one ton of a flame retardant, polybrominated biphenyl (PBB), found its way into animal feed that was distributed throughout the entire state. Before the accident was identified, herds of animals in all parts of the state were afflicted. Milk production plummeted and the animals became sickly. In addition, farm families were afflicted with debilitating disorders[18].

PBBs, like PCBs, are virtually indestructible, with the result that one ton has been recycling in Michigan since 1973 and has now spread into Ontario. This incident points up four lessons: 1) Once a chemcial accident such as this has occurred, there is no way to "clean up" completely; 2) The more sophisticated and deadly chemicals become, the greater the chance that a human error will cause serious harm; 3) Chemical accidents are often unnoticed until much later and then only by chance; and 4) If the staggering cows and weakened farmers of Michigan are indicators of the danger of PBBs, what can be expected if the six million tons of PBBs manufactured as a flame retardant begin to work their way into the environment?

These four episodes represent examples where a specific toxicant was identified. They make clear that humans are as much a part of the environment and are as vulnerable as any other living organism and they stress the fragility of all living systems in the face of chemical power. We must not make the mistake, however, of believing that ecotoxicity can be described in terms of single chemical episodes. Much more insidious, pervasive and harder to describe is the sum total of chemical contamination.

Ecotoxicity obviously still represents a vaguely defined area, not sufficiently circumscribed for the kind of scientific base policy-makers prefer. In establishing a scientific base for environmental regulation, it is not a question of choosing a defined science, classic toxicology, over an embryonic and undefined science, ecotoxicology. To consider this as the only alternative would trap policy-making for the next several decades in a conceptual rut. The dangers of basing policy on an inappropriate science, regardless of how tidy it seems, become evident from an examination of major policy decisions on controlling chemical contamination of the environment.

V. ENVIRONMENTAL CONTAMINANTS ACT (CANADA): A CRITIQUE

In 1976, in response to a deepening public concern about chemical contamination, the federal government proclaimed the Environmental Contaminants Act. Except for a relatively small number used in foods, drugs and pesticides, many chemicals hitherto were manufactured and sold without monitoring or regulation regarding their toxic implications. This Act represented a major attempt to gain control over chemical contamination in the environment. Several other Acts exist which also provide authority for regulating some aspect of environmental contamination. None has the scope or intent expressed in the Environmental Contaminants Act (see Appendix I for list of relevant Acts).

In brief, the Act empowers the Departments of Environment and National Health & Welfare to ban or restrict the use, manufacture or importation of any chemical. In order to regulate, the Environmental Protection Service (EPS) of the Department of Environment is empowered to gather information with respect to what chemicals are being manufactured and sold and to request toxicological information from the manufacturer or seller. Regulatory decisions will be made on each chemical or on a class of chemicals. As one of the first decisions, for example, the Minister of Environment, on the recommendation of EPS, banned the manufacture and importation of polychlorinated biphenyls (PCBs).

Brave as the Environmental Contaminants Act is, it will protect effectively neither the quality of the environment nor the quality of human life. There are two reasons for this. First, the ineffectiveness of the Act is sealed by a set of inappropriate assumptions that underlie the creation and projected implementation of the Act itself. The second derives from the first, because if the assumptions are inappropriate, it follows that implementation cannot be effective.

Assumptions Underlying the Legislation

Assumption 1: Environmental contamination can be controlled solely by regulating chemicals at the source, the manufacturing plant or the importer.

Critique: Chemicals wasted during use or when discarded find their way into the environment in some form. As an alternative to outright ban on all chemicals, the regulatory agency should be designing a system that controls chemicals from their manufacture, distribution and use to their ultimate disposal.

Assumption 2: Classic toxicology is good and sufficient to form the scientific basis for rules making.

Critique: Implicit in this assumption is the belief that the kind of information the science of toxicology generates predicts adequately the biological effects of chemicals in the environment. As discussed in Section III, this is not the case.

Assumption 3: The slowness of classic toxicology at carrying out tests is recognized and thus some chemicals will have to be declared more dangerous than others, receiving priority testing. This might be called the "sore-thumb" approach.

Critique: This approach was designed, perhaps, because there are indeed a number of sore-thumb contaminants - mercury, DDT, dieldrin, PCBs, PBBs and others. The Act is adequate to deal with these chemicals and undoubtedly will take care of them in due course. But there is no assurance that the Act, having dealt with the most visible contaminants, will be able to cope with all the rest. The situation is analogous to a police list of the ten most wanted criminals. If these ten were apprehended, would it reduce crime?

There is reason to suspect that the more serious aspects of environmental contamination results from the accumulated effects of the tens of thousands of contaminants in interaction with one another in the environment.

The contribution of any one may be so minor as to seem inconsequential, but cannot be ignored. For example, it has been demonstrated that two chemicals separately may not cause cancer in laboratory animals, but together they may become deadly. Because of the lack of precise information, one can only surmise the toxic effects of the unlimited combinations of environmental contaminants.

Should one seek a single high-profile chemical culprit for the goitres and lip cancers of Lake Ontario fish, or should one accept that their aquatic environment in general has deteriorated? The type of public policy formulated differs enormously depending on the perception of the problem.

Assumption 4: Chemical contamination is inevitable and therefore the best that the public can expect is that its worst effects may be minimized.

Critique: This assumption stems from the laissez-faire attitude towards environmental contamination that has been current for so long. As a consequence, industries and commercial establishments have approached industrial design with freedom to discharge waste as an essential right. Industries have been reluctant to redesign processes already in place in order to minimize contamination.

It is not just a question of industrial practice because, in the disposal of chemical waste, household practices (household products wind up in the sink or garbage sooner or later) play a major role. So this assumption could be rephrased: that industrial, commercial, and personal life styles cannot and should not be changed. In effect, the environment is being asked to adapt to the technical life style of the industrialized nations, which could be fatal.

Assumption 5: A certain amount of contamination can be tolerated as an acceptable risk.

Critique: This assumption leads to the belief that the aim of environmental control is to prevent contamination from exceeding a threshold. The degree of toleration or acceptable limit, however, is often related directly to the economic benefit. Thus when economic development includes environmental contamination, the more economic benefit expected, the more contamination decision-making bodies are prepared to inflict on the environment.

Assumption 6: This assumption was well stated by J.C. Hedley, a University of Missouri economist, in a paper prepared in 1972 for Resources for the Future: "The environment exists, most would agree, for man to use, to care for, and to enjoy."

Critique: Chant, in response to that statement, pointed out that the environment exists - *period*[19]. Implicit in Hedley's statement is that humans are the centre of the biological world. This anthropocentricity, perhaps more than any other attitude, lies at the root of society's difficulty in coming to grips with environmental reality.

The human-centred world often puts environmentalists in the awkward position of having to evaluate environmental contamination in terms of its direct human impact. Anyone with a feel for ecological processes recognizes that any contamination of the natural environment affects the entire ecosystem in some way. The high incidence of environmentally-caused human cancer may be a strong warning of what is happening to the environment at large.

Policy-makers ignore at their peril the strength of the public feeling for the intrinsic integrity of the environment. Thus when groups protest violations of the environment, they may not be doing so from a basis of hard scientific evidence, but rather from a gut feeling that something is wrong. Just because our society has been anthropocentric for a long time, there is no reason to believe it should remain forever so.

Implementation of the Environmental Contaminants Act

In the year (1976) the Environmental Contaminants Act was proclaimed in Canada, a similar act, the Toxic Substances Control Act (TSCA) was passed in the United States, founded on the same set of inappropriate assumptions. TSCA is administered by the Environmental Protection Agency (EPA). Both Acts are being implemented in a parallel manner, both faced with the same

difficulties. Because the Canadian chemical industry is largely integrated through ownership and trade with the U.S. industrial sector, implementation of the Canadian Act depends on the industrial policies set by the parent companies, as they respond to the requirements of TSCA. Thus in this commentary on the Canadian Act, reference must be made to the parallel implementation of TSCA.

There are eight basic problems in trying to implement the Environmental Contaminants Act.

1. Administration of the Act: The act is administered by two federal departments, National Health & Welfare, and Department of Environment. In addition, any decision-making must involve the corresponding departments in the ten provinces. The potential for intergovernmental squabbling, delay and superfluous paper work is immense.

Splitting the jurisdiction between two federal departments, unfortunately, reinforces a *de facto* assumption that humans and the environment are separate. Those responsible for public health are concerned only with chemicals that impact directly on humans, for example, chemical residues in food. This narrow attitude downplays the significance of chemical effects on other species.

One consequence of the split is that two types of data on harm are being gathered. National Health & Welfare has a team of toxicologists that carries out specific experiments and assesses toxicological data from other sources concerning harm and potential harm to humans. This activity is carried out in the classic toxicology style.

Quite separately, the Department of Environment, through its network, gathers evidence of chemical harm to fish, wildlife and plants. The usefulness of these data will be discussed later in this paper.

The Act allows both types of data to be used for rules-making and the inclusion of environmental data is welcomed as a basis for decisions. Political reality, however, dictates that the human data will carry more weight. The decision on PCBs, for example, was politically acceptable because of substantial evidence of harm to humans.

It would have been preferable to have a single jurisdiction that recognized the interdependence of all species and treated the living environment as a whole. If this were to be the case, the concept of ecotoxicity described in Section IV would be promoted much more quickly.

2. Logistics: The first task of EPS has been to draw up an inventory of chemicals used in commerce. The Act provides for declaration of new chemicals and new uses of existing chemcials. In addition to the 60,000 or more chemicals in commerce, which might be termed chemicals identified in catelogues, companies are asked to report all the intermediates used in chemical manufacture, whether isolated or not. Because of this, the list could easily multiply five-fold. Apart from the chemicals already in production, the Office of Toxic Substances (OTS) of EPA in the U.S. estimates that the number of new notifications in that country will be at least 1,000 per year[20].

Canada will rely heavily on EPA to acquire and maintain this inventory, but the sheer volume of information pouring into the OTS exceeds any capacity to assimilate it. For example, if use data are to be reported in the inventory of existing chemicals, it may be necessary to require reports from processing as well as manufacturing firms. This could increase the number of reporting firms to about 500,000. A major manufacturer may make 5,000 - 10,000 different chemicals. If an average of only 10 chemicals per manufacturer or processor is assumed, and an average time of six minutes per chemical for coding and verification, simply processing the reports so that they could be computerized would require about 250 person years. This is just the clerical operation. How is all this information to be evaluated by professional scientists?

It is clear that the logistics of describing and regulating the chemical world as it now exists are formidable. Even if EPA were granted unlimited funds to set up an organization commensurate with the task, there would be no improvement in administration of TSCA, because the trained professionals the system would require do not exist. Personnel needs will be discussed later on.

Administratively, EPA, with its much larger resources than EPS, can process no more than 50 TSCA rules at most in any one year[20]. Some observers feel that the number will be far less. Insofar as the rules sometimes cover classes of chemicals rather than individual compounds, the number of chemicals covered could be larger than the number of rules.

Under the circumstances it is difficult to see how the Canadian agency, with its tiny staff, hopes to make any realistic impact on this backlog of chemicals, let alone keep up with the 1,000 or more new chemicals introduced into commerce every year.

3. Toxicology: To make rules presupposes the existence of data on which to base decisions. It has been estimated that for more than 90 percent of the chemicals potentially covered by the Environmental Contaminants Act, no published toxicity data of any kind exist. Some data may be available in industry and government files but these are quite limited. EPS has no facilities to do toxicological work. National Health & Welfare, although possessing laboratories, lacks the capability to study more than a few compounds.

The intent of the Act is that the producers and marketers will provide the toxicological data. Regardless of who produces the data, government or industry, they cannot be produced quickly. The trained personnel do not exist, for the total community of toxicologists in the U.S. and Canada is small. This community, for example, could test no more than 500 chemicals a year for carcinogenesis, using one species of animal. If two species were used, the number would be halved. With 1,000 chemicals a year entering the market, toxicologists even with the best of intent, could not evaluate more than a fraction.

4) Priorities: In a practical sense, EPS must establish priorities. At present, the relevant factors of exposure and adverse effects are used. Exposure can be further subdivided into extent, intensity and duration, i.e., how large a population is exposed to how much of the chemical for how long. The nature of the target also is a factor. Adverse effects can be divided into human health and environmental effects. For human health, there is an important distinction between acute and chronic effects.

Data, unfortunately, are rarely available on the relevant factors with the exception of acute human health effects. Therefore, a variety of surrogates are used, including animal data, and chemical properties, e.g., volatility, reactivity. Data on acute toxicity (LD_{50}) are sometimes available. Data on adverse environmental effects are usually limited to acute toxicity in one or two forms of vertebrate wildlife.

The priorization of chemicals (the sore-thumb approach), therefore, becomes highly subjective, dependent on nomination of chemicals by informed individuals. EPS, for example, circulated requests among the Canadian scientific community for nominations to a list of high priority chemicals (See Appendix II for the details of this survey). EPA in a similar activity has a goal of producing a list of 50 chemicals ranked in order of priority for decision[20].

Because of the weak data base, establishment of a priority list is reduced essentially to a lottery. Aware of this, the chemical industry raised considerable opposition to the whole procedure, in particular those companies who saw their bread and butter chemicals at the top of the list. Thus enters another dimension - political pressure - to an already subjective process.

5. Scientific Personnel: There are few professional toxicologists relative to chemists in Canada, one estimate being about 100, of whom most work in government. The rest are sprinkled throughout university departments. Few toxicologists are employed in the Canadian chemical industry. Thus Canada is essentially dependent on the scientific personnel working in the U.S.

Enactment of TSCA overnight created 1,000 openings for toxicologists, at least 500 at the PhD level, half in industry and half in EPA. One estimate is that there are no more than 5,000 scientists working in the general area of toxicology in the U.S.[21]. Of that number, less than 1,000 are working as professional toxicologists, that is, assessing the hazards of chemicals. The normal rate of training is not very high. At the moment, less than 150 post-graduate students are working in the field of toxicology.

The scramble for qualified toxicologists in the U.S. could endanger the availability of toxicologists to Canada where training facilities are lacking. The active training centres are located in the U.S. Young Canadians seeking experience in these centres will find it difficult to resist the siren call of U.S. industry and government laboratories.

6. Reliance on Foreign Data: It is clear that Canadian authorities will be dependent on data from U.S. and European companies on which to base their rules.

It is also clear that whatever the basis, generation of data will be arbitrary. First, there is the selection of what chemicals to test. Second, there is the question of what tests should be done. These decisions will be taken largely outside Canada. In addition, how will Canadian authorities validate the proffered information? Scandals among chemical companies and contract toxicological testing laboratories demonstrate that data are sometimes falsified, withheld and otherwise tampered with. A system that makes the fox responsible for counting the chickens leaves much to be desired.

One answer would be to remove all toxicological testing from industrial responsibility and install it in an independent agency, preferably an international one. Whether the testing is done by private companies, by special agencies, or by government, society pays for it.

7. Responding to the U.S. Initiative: Because of similar lifestyles, most of the chemicals used in the United States are probably used in Canada. It is unlikely that Canada will develop the technical and administrative infrastructure comparable to that in EPA, and thus it will become dependent on U.S. initiative. Much of the Canadian bureaucratic effort in government could be taken up in responding to American decisions, whether good or bad. For example, if the Canadian regulation with respect to a chemical is more stringent than that of the U.S., the international chemical companies can simply decide that the Canadian market is not worth the bother. On the other hand, if the regulations are weaker, Canada becomes a dumping ground for chemicals that cannot legally be sold in other countries.

8. Canada Is Not Part of the Action: It will be very hard to control the complex system of manufacture, use and disposal of chemicals solely through a rule book. We must create a sense of environmental responsibility in the chemical industry and the public. Above all, successful control requires strong public support.

How is that support to be obtained? Passage of TSCA in the U.S. has sparked an enormous amount of public debate and discussion. For the first time in their careers, chemists, chemical engineers and managers of chemical industry commenced to think about the biological effects of the products they make. It is hard to believe, regardless of how TSCA progresses, that the situation will ever return to the "environment be damned" philosophy previously held by many in the chemical industry. In this sense, passage of TSCA has been a positive step.

In contrast to the birth of TSCA, the Environmental Contaminants Act entered the public domain in Canada with little fanfare and no public debate. As an indication of the low interest, staff barely adequate to keep up with EPA rule making has been assigned in EPS to manage the Act. The lack of leadership of the Department of Environment in helping Canadians identify the problem and in rallying the necessary public support for effective control of chemical contamination is cause for concern.

VI. CONCLUSIONS AND RECOMMENDATIONS

Chemical contamination of the environment is one of the most deadly forms of contamination because it affects profoundly all forms of life everywhere on the globe. Present legislation cannot cope with the realities of industrial production and the indiscriminate use of chemicals. The Department of Environment would be making a serious mistake if it put its resources into trying to make inadequate legislation work. Instead, the Department must look beyond, and design policies and encourage attitudes commensurate with the realities.

This report has described several aspects of the issue of toxic chemicals in the environment. In summary:

1. Chemical technology is outstripping our knowledge of the biological effects of chemicals. All chemicals, in some form, eventually end up in the environment, where they have the potential to cause harm to humans and to other species.

More than 63,000 man-made chemicals are now in commercial use, and that number is increasing at a rate of about 1,000 per year. Enough is known about the few hundred chemicals that have been studied to demonstrate serious harmful effects to the natural environment and to humans. About most, however, we know virtually nothing; most have never even been tested. Hence the concern of the Canadian Environmental Advisory Council.

2. Classic toxicology is unable to come to grips with the large number of chemicals now in our environment, in particular in an appreciation of their complex interactions. There is a need to develop an expertise in ecotoxicology which can deal with problems of ecological and biological effects of phenomena such as long term exposure of humans and other animals to trace amounts of chemical complexes. The number of trained ecotoxicologists now available is grossly inadequate for the urgent jobs at hand.

3. The urgency and importance of the problems posed by the sea of chemicals contaminating our environment, and the frightening rate at which the numbers are increasing, do not seem to be recognized fully by the federal government and other jurisdictions in Canada.

The Science Council Report, "Policies and Poisons", for example, specifically cited the lack of perception by senior officials of the gravity of serious chemical contamination and, worse, a lack of sensitivity to their own impotence, all masked by secret deliberations[22].

4. The federal legislative powers now in place, notably the Environmental Contaminants Act, are not adequate to meet the realities of chemical contamination of the environment. Their philosophical bases are not attuned to these realities. Their procedures are better adapted to coping with single chemical-single effect relationships than with the often subtle and indirect effects of chemical complexes, often acting in minute quantities over long periods of exposure.

5. Canada has not been aggressive in pursuing the search for alternatives to chemicals on which we now rely so heavily, or in developing safer chemicals to replace some of the more hazardous ones now in use.

The Canadian Environmental Advisory Council believes that ecotoxicity is one of the most serious threats to human and environmental wellbeing now confronting Canadians. This conviction is supported by the Resolution on Toxic Chemicals taken at the Third Joint Meeting of Environmental Advisory Councils (see Appendix III) held at Brudenell, P.E.I., in June, 1978 and forwarded to the Canadian Council of Resource and Environmental Ministers (CCREM). It is on the basis of this widely shared concern that the Council has formulated its recommendations to the Minister of Environment. They are as follows, divided into three categories:

A. Recommendations for Action within the Department of Environment

1. A senior official of the department, preferably an Assistant Deputy Minister, should be given responsibility for all departmental activities and powers related to the control of the release of toxic chemicals into the environment.

2. An internal coordinating committee on toxic chemicals should be appointed under the leadership of the senior official referred to in Recommendation #1. This committee should be charged with the following responsibilities:

a) To coordinate within the Department all activities related to chemical contamination of the environment, including research, policy development and regulations.

b) To coordinate the drafting of new legislation.

c) To coordinate the relations between the Department and the provincial authorities related to chemical contamination of the environment.

3. The Minister should initiate policy studies on the development of second-generation legislation more in tune with the realities of the host of chemical contaminants in the environment and the concepts of ecotoxicity.

This new generation of legislation must be designed from the point of view of the environment. It should be based on two premises: 1) The environment exists and should not be despoiled; and 2) We are ignorant of the details of environmental toxicity.

4. The Minister should give high priority to substantially increasing the work-years of effort in the Department allocated to the research support and administration of the present Environmental Contaminants Act. Moreover, we recommend a greater decentralization across Canada of the Department's activities related to the Act and that much more local field testing for chemical contaminants be carried out.

5. The Department of Environment should take initiative in ensuring the rapid development of simple, quick and inexpensive testing procedures for determining the toxic effects of environmental contaminants, especially those suspected of carcinogenicity, mutagenicity and teratogenicity.

6. In implementing the Environmental Contaminants Act, and when developing second-generation legislation (see Recommendation #3), the Department should provide for the restriction or prohibition of the use of certain chemicals, classes of chemicals, and combinations of chemicals if there are reasonable grounds to suggest that such use is harmful to humans and/or the environment.

We also recommend that the new legislation require the proponent of the use of a chemical to prove beyond reasonable doubt that the chemical will have no deleterious effect, immediately or in the forseeable future, on the environment and/or human well-being.

7. To facilitate research on and understanding of ecotoxicity as widely as possible, we recommend that all toxicological and analytical data held by the federal government or submitted to it by industry to support the use of a chemical be in the public domain. This freedom of access should also apply to statistics on amounts in use.

B. Recommendations for Action by the Federal Government

8. An interdepartmental coordinating committee should be established under the leadership of the Department of Environment and with representatives of other interested departments and agencies, to be responsible for all aspects of chemical contamination of the environment. This committee should be empowered to coordinate environmental monitoring research, policy development, and the development and application of legislation. It should also coordinate federal-provincial relationships with regard to chemical contamination.

Jurisdictional responsibilities for environmental contaminants understandably are assigned to a number of federal departments and agencies. It is essential, however, that there be one centre of responsibility that transcends the other departments and agencies in these matters and has the authority to coordinate their efforts. We recommend that the Department of Environment be assigned this central role.

The interdepartmental coordinating committee should be the focal point, in concert with the Department of External Affairs, for developing and expressing Canada's international interests in ecotoxicity and for interacting with international agencies such as WHO, FAO, OECD, and UNEP, active in the field of chemical contamination.

9. The Department of Environment should give leadership in persuading the federal government and Canadian society as a whole to adopt a longer time frame and broader perspective in attempting to resolve apparent conflicts between perceived economic benefits and environmental well-being, particularly with respect to the use of chemicals which are harmful to the environment.

C. Recommendations for Action External to the Federal Government

10. The Minister should take the initiative among his appropriate colleagues, in enabling one or more major government-university centres in ecotoxicity to be established without delay. The Department of Environment is not going to fulfill its mandate if it cannot recruit appropriately educated people. The Department should take the initiative in focussing educational and research needs. It must avoid falling into the trap, however, of encouraging production of more specialists trained in the patterns of a bygone era. It would be easy, for example, to establish additional facilities to train classic toxicologists. We do not believe the interests of the Department or the country would be served by any such program. It is clear that the new generation of researchers, technologists and administrators required by the policies recommended in this report do not fall comfortably into any existing educational category. It is also clear that without the imagination and appropriate skills of large numbers of people, the new approach to environmental protection and creation of alternative technologies (Recommendation 11) will be aborted.

11. The Government Organization Act (Bill C-35, 1978) clearly entrusts the Department of Environment with the responsibility to share information and to develop a public awareness of environmental problems. The Minister should take leadership in encouraging Canadians to embark on an aggressive search for economic, industrial and biological alternatives to the use of chemicals which contaminate the environment. When the use of chemicals that contaminate the environment is essential, Canadian should be encouraged to apply the closed-loop* philosophy wherein methods for the safe and effective ultimate disposal of all chemicals produced becomes an integral part of their production, use and management.

The Short and the Long

In keeping with Lord Russell's dictum, what we are recommending in this report is official encouragement for an environmental wisdom.

Many decision-makers will dismiss such wisdom as economically impracticable at the present and consider that in any short-term analysis, perceived economic beliefs must override environmental concerns. This policy, of course, has been the pattern and many people despair of ever changing it. Perhaps one reason is that policy makers in promoting economic benefits tend to view environmental concerns as strictly negative, e.g., don't build, don't make.

We would consider our report a failure if that is the impression it leaves. What we advocate are positive alternatives that are environmentally sound. To return to our pesticide example, biological controls would require skilled people and appropriate organizations. It would be fair to say that

---

*In a closed-loop, the manufacture, distribution, use and ultimate disposal of a chemical are carefully monitored and controlled.

in such an enterprise, more people would be employed than are currently employed making and applying pesticides. It is beyond the scope of this report to spell out details of the economic advantages of alternative technical approaches, but in general, environmentally sound enterprises are job intensive and economically productive.

Finally, we are confident that everyone, citizen, industrialist, entrepreneur, politician, wants to live in a stable, viable society. We believe that over a long time-framework, the alternatives suggested and the specific recommendations made, will serve the interests of everyone.

REFERENCES

1. Quoted by John H. Knowles in *Doing Better and Feeling Worse*. Edited by J.H. Knowles, New York, Norton, 1977.

2. Commoner, B., *The Closing Circle*. New York, A.A. Knopf, 1971.

3. Storck, W.J., "Production rises for most major chemicals". *Chemical and Engineering News*, May 1, 1978, pp. 32-37.

4. Maugh, T.H., "Chemicals: How Many Are There?" *Science*, 199, 1978, p. 162.

5. Sonstegard, R.A., "Environmental Carcinogenesis Studies in Fishes of the Great Lakes of North America". *Annals of New York Academy of Sciences*, Vol. 298. Aquatic Pollutants and Biologic Effects with Emphasis on Neoplasia. 1977, pp. 261-269.

6. "Kennedy Calls for Upgrading Science of Toxicology". *Food Chemical News*, October 3, 1977, p.32.

7. Paget, G.E., "The Design and Interpretation of Toxicity Tests", in *Methods in Toxicology*. Editor, G.E. Paget. Oxford, Blackwell, 1970.

8. Higginson, J. "Present trends in cancer epidemiology", in *Canadian Cancer Conference*. Editor, J.F. Morgan. Toronto, Pergamon Press, 1969.

9. "Notes on Pollution, Energy and Fuel". *Chemical and Engineering News*, January 26, 1976, p.40.

10. Gass, G.H., Coats, D., Graham, N. "Carcinogenic dose-response curve to oral diethylstilbesterol". *Journal of National Cancer Institute*. 33, 1964, pp. 971-977.

11. *Environmental Issues 1976*. Scientific Committee on Problems of the Environment (SCOPE) of the International Council of Scientific Unions (ICSU), August, 1976.

12. "If all the sea were PCB ...". *Food, Cosmetic Toxicology*, 11, 1963, pp. 131-144.

13. Eisenreich, S.J., Hollod, G.J., Johnson, T.C., *Accumulation of PCBs in Surficial Lake Superior Sediments: Atmospheric Deposition*. Limnological Research Center, University of Minnesota, Minneapolis, MN, 55455, 1979.

14. Shea, K., "PCB World Wide Pollutant That Nobody Notices". *Environment*, 15, November 1973, pp. 25-28.

15. Nigan, P.C., "Chemical Insecticides", in Prebble, M.C., editor, *Aerial Control of Forest Insects in Canada*. Environment Canada, Ottawa, 1975.

16. May, E.E., "Canada's Moth War". *Environment*, 19 (6), 1977, pp. 16-24.

17. Peterson, J., "Seveso: The event". *Ambio*, 7 (5-6), 1978, pp. 232-233.

18. Stevens, W.K., "Events in Michigan Revive Concern over Effect of PBB in Mother's Milk". *New York Times*, January 2, 1977.

19. Chant, D.A., "Biological Reality and Economic Analysis of Pesticide Policies". A paper prepared for *Resources for the Future, Inc.*, May, 1972.

20. "Setting Priorities for Chemicals under The Toxic Substances Control Act". Report of a Workshop sponsored by *The Conservation Foundation*, 1717 Massachusetts Avenue, N.W., Washington, D.C., 20036, August 1977.

21 "Training Scientists for Future Toxic Material Problems", Annapolis, Md., September 8-10, 1977. *The Conservation Foundation.*

22. *Policies and Poisons.* Science Council of Canada, Report No. 28, Ottawa, 1977.

APPENDIX I

LEGISLATION UNDER WHICH SOME FORM OF REGULATION OF CONTAMINATION CAN BE ACCOMPLISHED

FISHERIES ACT

NAVIGABLE WATERS PROTECTION ACT

PULP & PAPER EFFLUENT REGULATIONS

CHLOR-ALKALI MERCURY REGULATIONS

ARCTIC WATERS POLLUTION PREVENTION ACT - CHAPTER 2 (1st Supp.)

ARCTIC WATERS POLLUTION PREVENTION REGULATIONS

CLEAN AIR ACT - CHAPTER 47

MIGRATORY BIRDS CONVENTION ACT - CHAPTER M-12

CANADA WATER ACT - CHAPTER 5 (1st Supp.)

NORTHERN INLAND WATERS ACT - CHAPTER 28 (1st Supp.)

PHOSPHORUS CONCENTRATION CONTROL REGULATIONS

LEAD-FREE GASOLINE REGULATIONS

PETROLEUM REFINERY LIQUID EFFLUENT REGULATIONS

AMBIENT AIR QUALITY OBJECTIVES

LEADED GASOLINE REGULATIONS

AMBIENT AIR QUALITY OBJECTIVES, NO. 2

OCEAN DUMPING CONTROL ACT

ENVIRONMENTAL CONTAMINANTS ACT

SECONDARY LEAD SMELTER NATIONAL EMISSION STANDARDS REGULATIONS

METAL MINING LIQUID EFFLUENT REGULATIONS

METALLURGICAL INDUSTRIES ARSENIC INFORMATION REGULATIONS

METALLURGICAL INDUSTRIES MERCURY INFORMATION REGULATIONS

MEAT AND POULTRY PRODUCTS PLANT LIQUID EFFLUENT REGULATIONS

NOTE: *Appendix II following contains the original letter circulated in 1976 by the DOE/NH&W Environmental Contaminants Committee soliciting comments on the list of priority chemical substances. Following receipt of responses and further study, the list was divided into four categories. Information on the second stage of the establishment of the list is available from the office referred to in the original document, which is annexed here to indicate the procedure used to develop the priority list.*

APPENDIX II

DOE/NH&W ENVIRONMENTAL CONTAMINANTS COMMITTEE
DEVELOPMENT OF A LIST OF PRIORITY CHEMICAL SUBSTANCES UNDER THE ENVIRONMENTAL CONTAMINANTS ACT

The Departments of Environment and of National Health and Welfare are jointly developing a list of priority substances (or in some instances classes of substances) to be investigated and/or specified under various Sections of the Environmental Contaminants Act. The attached general list of problem substances has been drawn up by the Environmental Contaminants Control Branch based upon inventories of those chemicals which are presently being studied or have been designated as hazardous or toxic by such organizations as EPA, NIOSH, WHO and NRC Canada.

Various factors taken into account during the development of these lists included persistence, movement and accumulation of the chemicals, toxic and chronic effects on living organisms including man, and industrial and commercial use of the chemicals. Mnay of the chemicals have been observed during residue analyses of fish and aquatic birds and during surveys of ambient and waste water and drinking water.

Since pesticides are covered by Agriculture Canada's Pest Control Products Act, they have not been considered in great detail. However, the highly persistent existing ones are included in a number of existing lists of environmental chemicals.

Of major interest are two groups of chemicals: 1) those which resemble chemicals already known to be persistent or hazardous; and 2) new or existing ones presently replacing chemicals removed (voluntarily or by legal action) from industrial use.

From this general list of problem substances a small group (List A) of substances requiring immediate detailed study of their chemodynamics is to be selected, that is, those substances that are presently in or are entering the environment and could accumulate to levels that could constitute a danger not only to the environment but also to human health. Secondly, a larger group of 20 to 30 potentially dangerous substances (List B) will be selected for surveys under the Environmental Contaminants Act, leading to a detailed analysis of industrial production import, use and likely loss to the environment.

We are anxious to canvass the widest possible range of opinions and receive the views of experts who are actively working in the field of environmental contaminants. Any suggestions for additions to the general list would be welcome. Secondly, we are requesting that you nominate a group of chemicals to be placed on List A and a larger group for List B. Excerpts from the list of Criteria for Assessment of Ecotoxicity (proposed by OECD), which may be helpful for your evaluation, have been enclosed. While these criteria mainly stress the human health aspect, for our purposes hazards to any organisms or ecosystems are of importance. Because we are requesting an opinion based on your knowledge in this field rather than your assessment of a full-scale literature search, we hope that you will find it possible to respond within three weeks after receipt. Furthermore, we would be most interested in being made aware of any special research or other study you are currently undertaking on specific chemical substances. Would you please indicate if this is a personal response or if it represents the collective response of a group or organization. We hope that you will feel free to distribute this list to any experts in the field who, you think, would be interested in responding. In this connection, if this is a duplicate copy please forgive us. If you have any questions or require further information please contract:

Ruth Demayo
Environmental Contaminants Control Branch
Environment Canada
Cttawa, Ontario, K1A 0H3

Telephone No. 819-997-3201

Your cooperation and comments would be greatly appreciated.

J.E. Brydon
Chairman
DOE/NHW Environmental Contaminants Committee

APPENDIX II (cont'd)

EXCERPTS FROM THE LIST OF CRITERIA
FOR ASSESSING ECOTOXICITY (PROPOSED BY OECD)*

The ecotoxicity of a substance is here taken to mean its impact on the ecological equilibrium, i.e. on all relationships between living organisms, including man and the environment in which they live.

DESCRIPTIVE CRITERIA

1. Acute Toxicity

Only the direct hazard to man assessed by experiments on laboratory mammals is considered here.

Acute toxicity is generally measured in terms of the LD_{50} or LC_{50} (dose or concentration lethal to 50 percent of individuals each receiving a single dose of the substance). The experiments may be carried out on different mammals: rats, mice, guinea pigs, rabbits, dogs, pigs, monkeys, etc. According to the use to which the substance is put, it may be adminstered orally, percutaneously, intraperitoneally, and so on.

2. Chronic and Miscellaneous Toxicities

The following may be taken into consideration if necessary:

- the sub-chronic toxicity (repeated daily doses to a rat for 90 days), the chronicity factor (ratio of acute LD_{50} to daily LD_{50}), any organic reaction, the effect on metabolism and the histological effects will be considered;
- cutaneous reactions;
- ocular reactions;
- the chronic toxicity. This study could be done on a one-year rat and possibly on a three-year dog;
- carcinogenesis;
- mutagenesis of the three generations;
- teratogenesis.

Studies on other living organisms: according to the applications of the substance, the environment in which it may end its life (target medium) and the amounts involved, the acute toxicity and possibly the chronic toxicity will be examined on other living organisms: bacteria, algae, cryptogams, phanerogams, arthropods, molluscs, fish, birds, etc.

3. Stability

This term encompasses the resistance of the substance to natural degradation agents taking account if necessary of the behaviour of its metabolites.

It is a matter of assessing the stability of the substance (in the terms given above) having regard to its physical and chemical properties, its expected applications and its target environment or environments. If model studies have been done in certain cases, it will be possible to give a numerical value for its half-life under specified conditions; otherwise, the expert will make a coarse evaluation of this half-life using the data available to him.

4. Disposal

This term refers to the propensity of the substance once it has become waste or surplus to requirements for destruction by artifical agents or appropriate treatment processes. The examination will take into account the usual concentration of the substance in the environment to be treated. Its behaviour will be examined as appropriate in a treatment or incineration plant, in a controlled dump or during conventional treatment of gaseous effluent.

---

*These criteria were circulated by the Environmental Contaminantc Committee with the original solicitation for comments.

Where appropriate, consideration will be given to the presence and toxicity, if any, of by-products arising from this process and of their own ecotoxicity. It is clear that this criterion can be specified only insofar as the product enters the environment via a path which can be monitored: sewerage, dumps, chimney stacks and so on. Otherwise it will be specified that the target media covered under criterion No. 9 are directly polluted, in the absence of any artifical disposal process.

5. Diffusion

It is important here to estimate the possible "inter-media" transfer of the substance as a function of its mobility from the environment in which it is used to another medium or other media. It will be necessary to examine not only the expected use of the substance (distribution and target media) but also its future having regard to its physical and chemical properties and stability. It will have to be decided whether it is certain that the product will remain in the medium of use until destroyed, or whether it can be entrained into other media by natural agents and whether it can enter a food chain albeit in trace quantities.

6. Accumulation

It is a question here of trying to evaluate the extent to which the substance is liable to concentrate at some point in the environment, either as a result of the action of different agents or otherwise. Such concentration may be a mere accumulation owing to the product's high stability combined with the impossibility of monitoring its entry into the environment, or a bioaccumulation owing to the fact that it enters a natural process involving living organisms. Allowance will be made for any burden ceiling in this accumulation process and it will be specified whether the bioaccumulation may be accompanied by phenomena of biomagnification.

7. Distribution

Here is a matter of looking into the inherent risks to the types of users for whom the product is intended.

8. Quantities

Here is considered the mass effect on the environment according to the national annual production level envisaged.

9. Target Media

It is a question here of determining the medium or media (usually the air, water, the earth or living organisms) in which the chemical substance and the by-products of its use end their life. In examining this criterion, consideration will have to be given to the extent to which it is possible to monitor the path followed by the chemical product into the environment through sewerage, refuse collection, chimney stacks, etc.

APPENDIX II (cont'd)

GENERAL LIST OF PROBLEM SUBSTANCES

PESTICIDES

Aldrin
Chlordane
DDT & metabolites
Dieldrin
Heptochlor
Lindane
Methoxychlor
Mirex
Toxaphene

HALOGENS

Chlorine - chlorides
Iodine - iodides
Bromine - bromides
Fluorides

ELEMENTS

Antimony
Arsenic
Beryllium
Bismuth
Boron
Cadmium
Chromium
Cobalt
Copper
Lead
Manganese
Mercury
Nickel
Radionuclides
Selenium
Thallium
Tin
Vanadium
Yttrium
Zinc

NON-METALS

Amines	α and β-naphthylamine ethyleneimine
Asbestos and glass fibers	
Benzene	brominated benzenes: hexabromobenzene chlorinated benzenes: hexachlorobenzene (HCB) trichlorobenzene 1,2- 1,3-, 1,4-dichlorobenzene dimethylaminoazobenzene nitrobenzene, chloronitrobenzene and chlorodinitrobenzene
Benzidine	Aminobiphenyl 4-nitrobiphenyl dichlorobenzidine
Biphenyls	chlorinated and polychlorinated biphenyls (PCB) brominated and polybrominated biphenyls (PBB): hexabromobiphenyl octabromobiphenyl chlorofluorobiphenyls 4-bromomethylbiphenyl chlorobiphenylol (ester) bis(chloromethyl) octachlorobiphenyls (new patent)
Carbazole	
Carbon tetrachloride	
Chlorinated adipate	
Chlorinated ethanes	chloroethane 1,2-dichloroethane 1,1,1-trichloroethane tetrachloroethane pentachloroethane hexachloroethane
Chlorinated paraffins	
Chlorinated dibenzofurans	
Chlorinated dibenzo-p-dioxins	2,3,7,8-tetrachlorodibenzo-p-dioxin

Chlorinated ethylenes	1,1-, and 1,2-dichloroethylene trichloroethylene tetrachloroethylene
Dechlorane (Mirex)	flame retardant
Dibromoethane	
Dichloropropane and dichloropropene	
Diphenylhydrazine	
Fluorocarbons	
Haloethers	Chloromethyl, chloroethyl and chloroisopropyl ethers mixed ethers, e.g. methylchloromethyl ether chlorinated anisole p-bromoanisole chlorinated diphenyl ethers brominated diphenyl ethers bis(chloroethoxy) methane
Halogenated and non-halogenated phosphate esters	
Halogenated selenophene and tellurophene	
Halomethanes	chloromethane dichloromethane chloroform bromomethane bromoform dichlorobromomethane mono-,di- and trichlorofluoromethane tetrafluoromethane
Hexachlorobutadiene	chloroprene (2-chlorobutadiene 1,3)
Hexachlorocyclopentadiene	(precursor to Mirex)
Mercaptans	
Nitrosamines	dimethylnitrosamine
Organosilicones	polymethyl siloxanes polymethylphenyl siloxanes
Organotin	
Pentachlorobromocyclohexane	
Phthalate esters	diethylphthalate dibutylphthalate
Phenols	brominated phenols chlorinated phenols: 0-chlorophenol 2,4-dichlorophenol pentachlorophenol tetrachlorophenol 2,4-dimethylphenol nitrophenols: mononitrophenol 2,4-dinitrophenol dinitrocresol cresols: chlorinated cresols cresylic acid creosote naphthols: chlorinated brominated
Polycyclic aromatic hydrocarbons and derivatives	anthracene benzanthracenes 9,10-diphenylanthracene chrysenes (benzophenanthrene) fluorenes acetylaminofluorene benzo (a) fluorene fluoranthene benzofluoranthene naphthalenes chlorinated brominated methylnapththalene acetonaphthalene

	phenanthrene	2-methylphenanthrene
	perylene	benzoperylene
	pyrene	methyl pyrene
		benzo (a,b) pyrene
		dibenzopyrene
		indenopyrenes
Styrene	chlorinated styrenes - e.g. octa and polychlorinated	
Terphenyls	chlorinated	
Tetrabromodihydroxyhexane		
Toluene	o-chlorotoluene pentabromotoluene dinitrotoluene	
Vinyl acetate		
Vinyl bromide		
Vinyl chloride	PVC	
Vinyl cyanide (acrylonitrile)		
Vinylidine chloride		

APPENDIX III

3rd JOINT MEETING OF ENVIRONMENTAL ADVISORY COUNCILS
BRUDENELL, P.E.I., JUNE 4-7, 1978

RESOLUTIONS

TOXIC CHEMICALS

Due to the extreme importance of potential harmful effects of various chemicals on the environment, the advisory councils recommend:

1. That participating councils request their respective Ministers to recommend to the CCREM the establishment of a federal provincial Task Force to initiate meetings with various federal and provincial regulatory agencies and representatives of the chemical industry, professional, scientific and consumer group organizations to consider, among other items:

   a) what, if any, classes of toxic chemicals either presently in production or being developed require immediate restrictive action and the timing of further restrictive actions;

   b) programs and necessary sources of funding for toxicology research and the development of environmentally safe uses for use of available chemicals on a coordinated basis involving government, universities, consumer groups and industry;

   c) means to develop and seek funding for educational and training programs to increase the number of environmental toxicologists and the awareness of Canadians regarding the inherent dangers of toxic compounds.

2. That individual participating councils review existing legislation and regulation pertaining to the use and control of toxic chemicals within their respective jurisdictions and, where appropriate, press for the strengthening of these controls.

LIST OF PUBLICATIONS

Annual Review 1973-1974. Part A - Activities 1973-1974 by Arthur Porter.
Part B - Problems and Priorities in the Canadian Environment by Pierre Dansereau

Annual Review 1975. Part A - Activities 1975 by Ian McTaggart-Cowan.
Part B - Significant Canadian Environmental Problems by J.P. Nowlan.

Annual Review 1976. Part A - Activities 1976. Part B - The State of the Canadian Environment 1976.

An Environmental Impact Assessment Process for Canada. Council Report No. 1, February 1974.

An Environmental Ethic - Its Formulation and Implications. Council Report No. 2, January 1975. By Norman H. Morse.

Harmony and Disorder in the Canadian Environment. Occasional Paper No. 1. By Pierre Dansereau. Council Report No. 3, 1975.

Environmental Aspects of Nuclear Power Development in Canada. Occasional Paper No. 2. By H.E. Duckworth, H.W. Duckworth, Arthur Porter and J.S. Rogers. Council Report No. 4, 1977.

Report of the Second Joint Meeting of Environmental Advisory Councils. May 1977, Fort San, Saskatchewan. Council Report No. 5, March 1978. Produced in collaboration with the Saskatchewan Environmental Advisory Council.

The Management of Estuarine Resources in Canada. Council Report No. 6, March 1978. By Irving K. Fox and J.P. Nowlan.

Reports of the First and Second Meetings of Public Interest Groups with the Canadian Environmental Advisory Council. Council Report No. 7, May 1978.

Towards an Environmental Ethic, March 1977. By D.A. Chant.